S2S4E
Climate Services for Clean Energy

Climate predictions for energy

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EERA JP Wind annual event, 17th-18th September 2018,Amsterdam

EERA European Energy Research Alliance JP WIND

This project has received funding from the Horizon 2020 programme under grant agreement n°776787.

Context and motivation

- Both energy supply and demand are strongly influenced by weather conditions and their evolution over time in terms of climate variability and climate change.

Like 15M

Thursday, Aug 30th 2018 1PM 25°C 4PM 26°C 5-Day Forecast

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Britain's turbines are producing 40% less energy as wind 'disappears' for six weeks across the UK causing record low electricity production

- Britain got 15 per cent of its power from wind last year — twice as much as coal
- Since the start of June, wind farms have been producing almost no electricity
- The 'wind drought' has seen July 2018 be 40% less productive than July 2017
- In the still weather, solar energy has increased by 10% to help cover the drop-off

By JOE PINKSTONE FOR MAILONLINE

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Context and motivation

- Energy sector routinely uses weather forecast up to several days. Beyond this time horizon, climatological data are used.

Met mast on Gwynt y Môr offshore wind farm (source: solar wheel)

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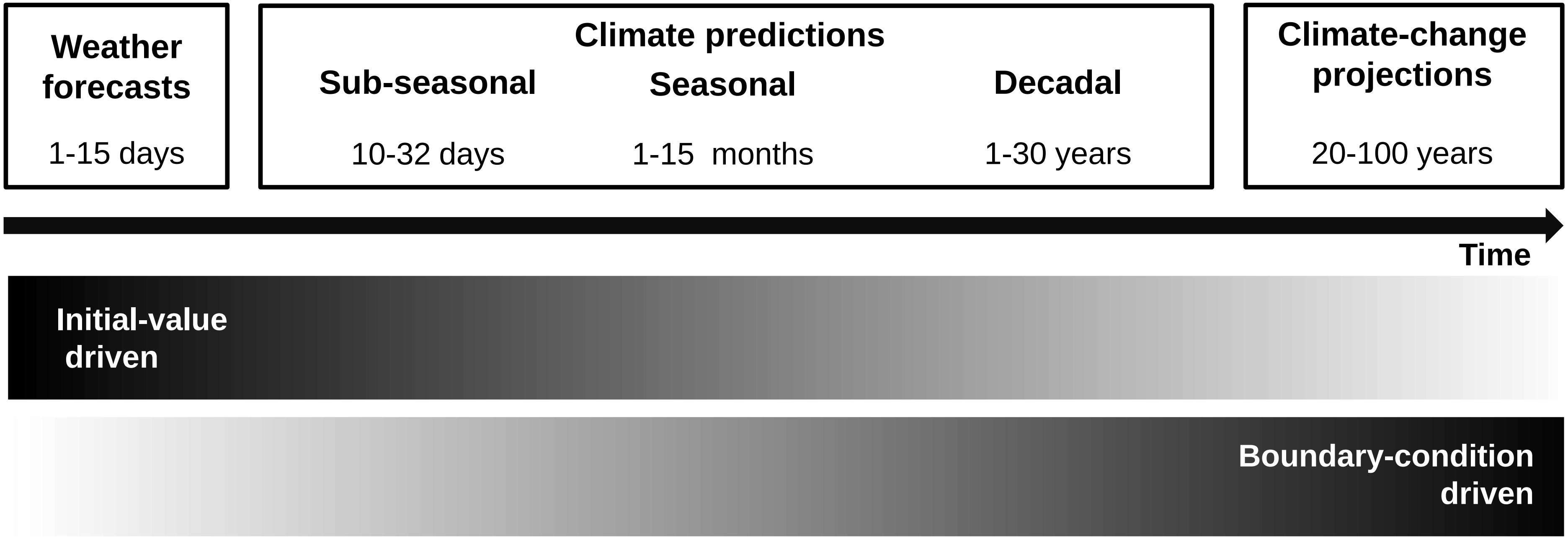
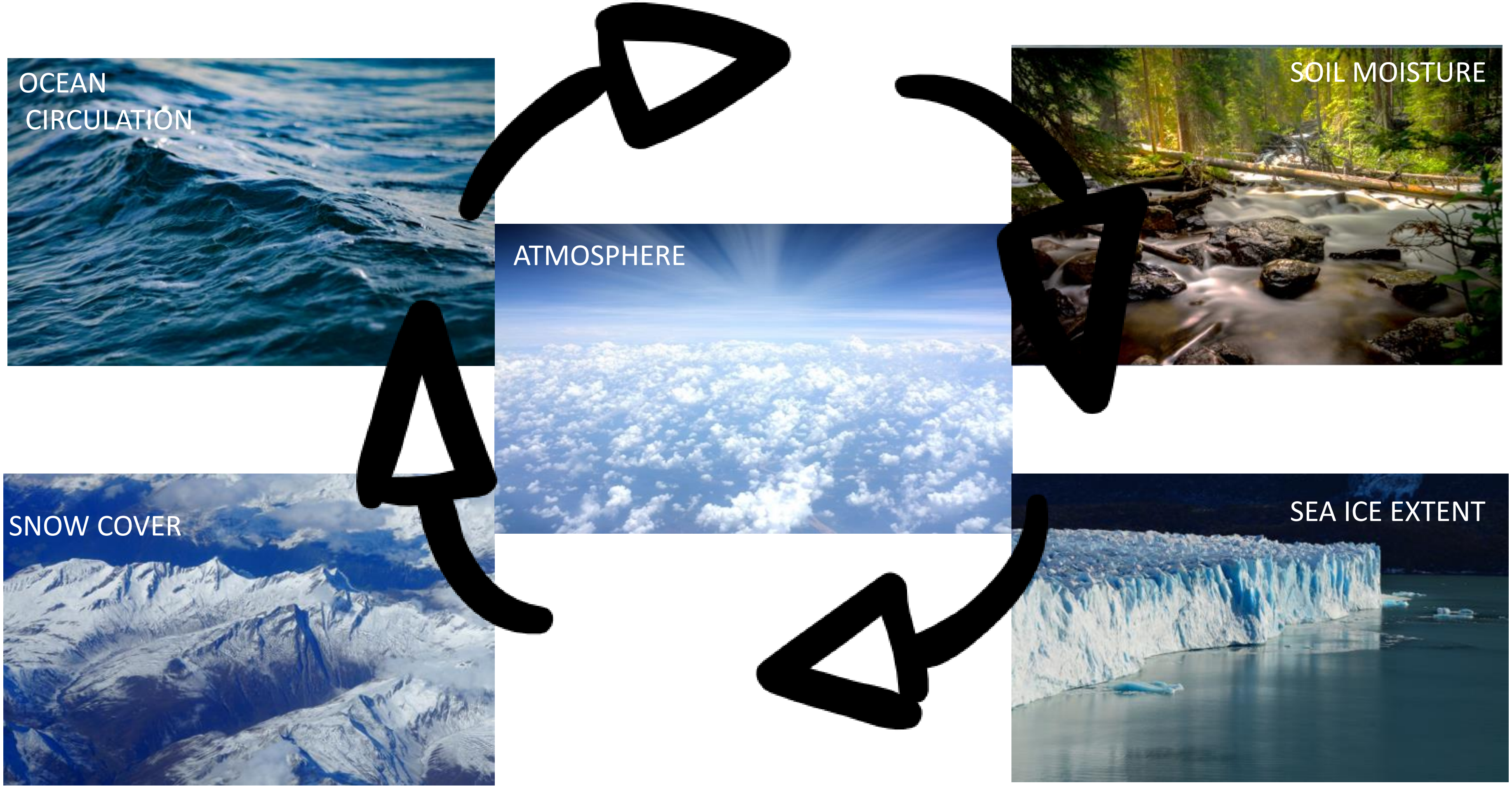
Climate predictions



Adapted from: Meehl et al. (2009)

Predictability

- How can we predict climate for the coming season if we cannot predict the weather next week? Slow components (sea surface temperature, soil moisture, etc.) force the atmosphere.



Objective

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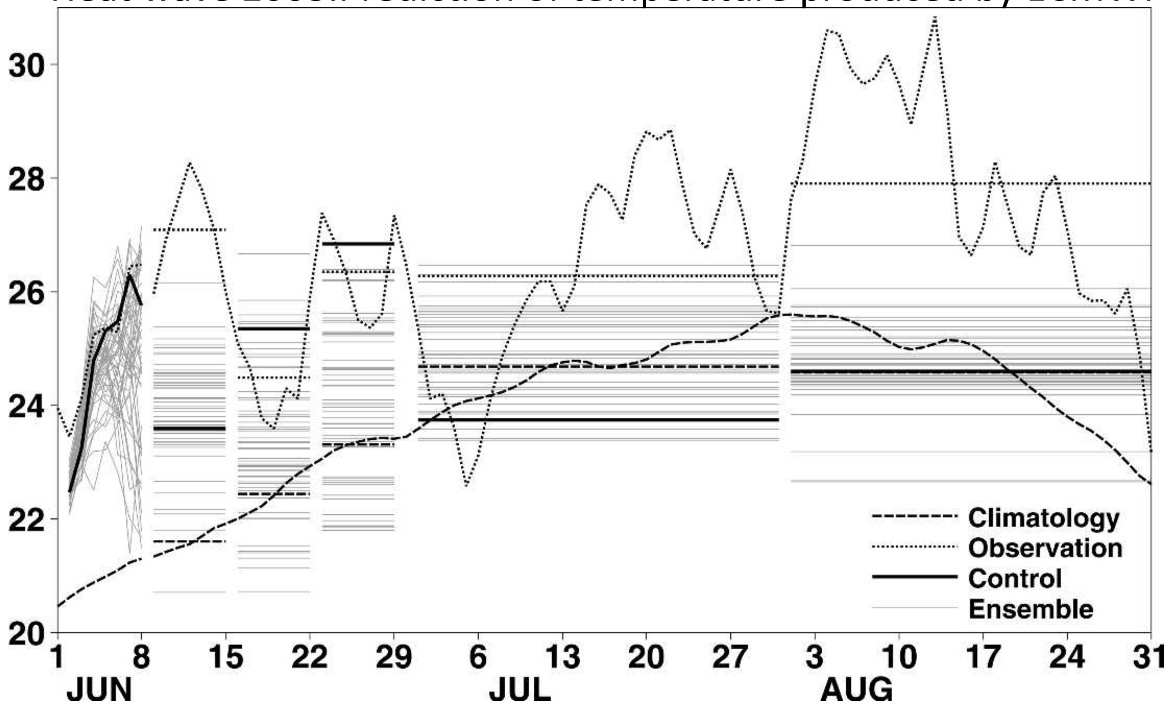
Objective

- S2S4E will offer an innovative service to improve RE variability management by developing new research methods exploring the frontiers of weather conditions for future weeks and months. The main output of S2S4E will be a user co-designed Decision Support Tool (DST) that for the first time integrates sub-seasonal to seasonal (S2S) climate predictions with RE production and electricity demand.

Heat wave 2003.Prediction of temperature produced by ECMWF



Observations (dotted) and forecasts (solid) made by ECMWF at the beginning of June of European 2-m land temperatures (C). Source: Rodwelland-Doblas-Reyes, 2006

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Applications

Weather forecast	Climate predictions: Sub-seasonal	Climate predictions: Seasonal	Decadal	Climate projections or multidecadal
1-15 days	10 d-1 month	1-6 months	1-30 years	20-100 years

Time

Applications for wind/solar/hydro generation

Post-construction decisions

Energy producers: commit energy sales for next day

Grid operators: Market prices and grid balance

Energy traders: Anticipate energy prices

Plant operators: planning for cleaning and maintenance

Post-construction decisions

Energy producers: Resource management strategies

Energy traders: Resource effects on markets

Plant operators: Planning for maintenance works, especially offshore wind O&M

Plant investors: anticipate cash flow, optimize return on investments

Pre-construction decisions

Power plant developers: Site selection. Future risks assessment.

Investors: Evaluate return on investments

Policy-makers: Asses changes to energy mix

River-basin managers: understand changes to better manage the river flow

Applications for demand

Daily operation decisions

Grid operators:

Anticipate hot/cold days. Schedule power plants to reinforce supply.

Energy traders: Anticipate energy prices.

Mid-term planning

Grid operators:

Anticipate hotter/colder seasons Schedule power plants to reinforce supply.

Energy traders:

Anticipate energy prices.

Long-term planning

Grid operators:

Anticipate addition of more capacity. Adaptation of transmission lines

Policy-makers:

Plan addition of more capacity. Understand changes to energy mix

S2S4E project

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Challenges and opportunities

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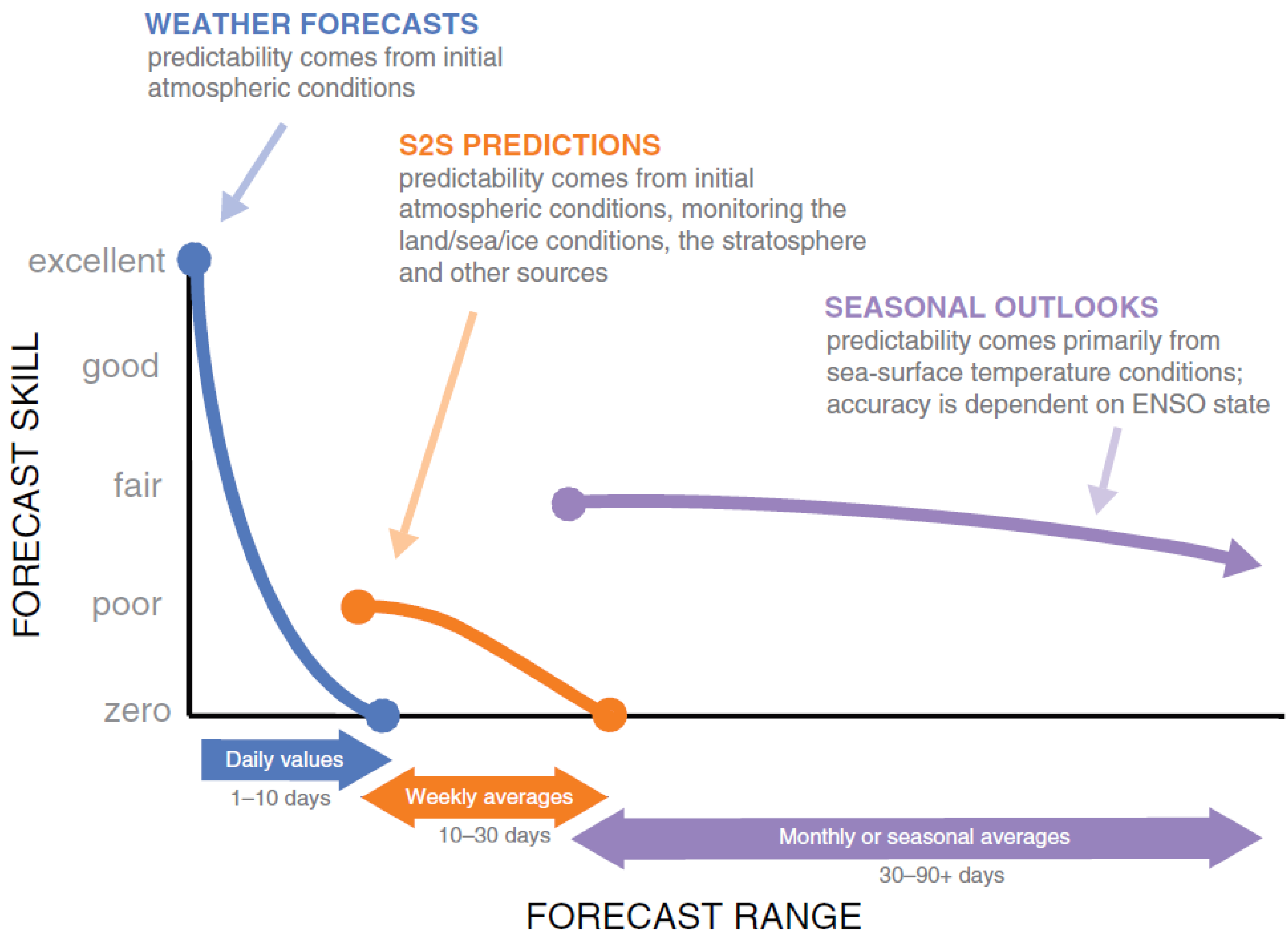
S2S Forecast range and skill



Qualitative estimate of forecast skill based on forecast range from short-range weather forecasts to long-range seasonal predictions, including potential sources of predictability. Relative skill is based on differing forecast averaging periods. (Source: White et al., 2017)

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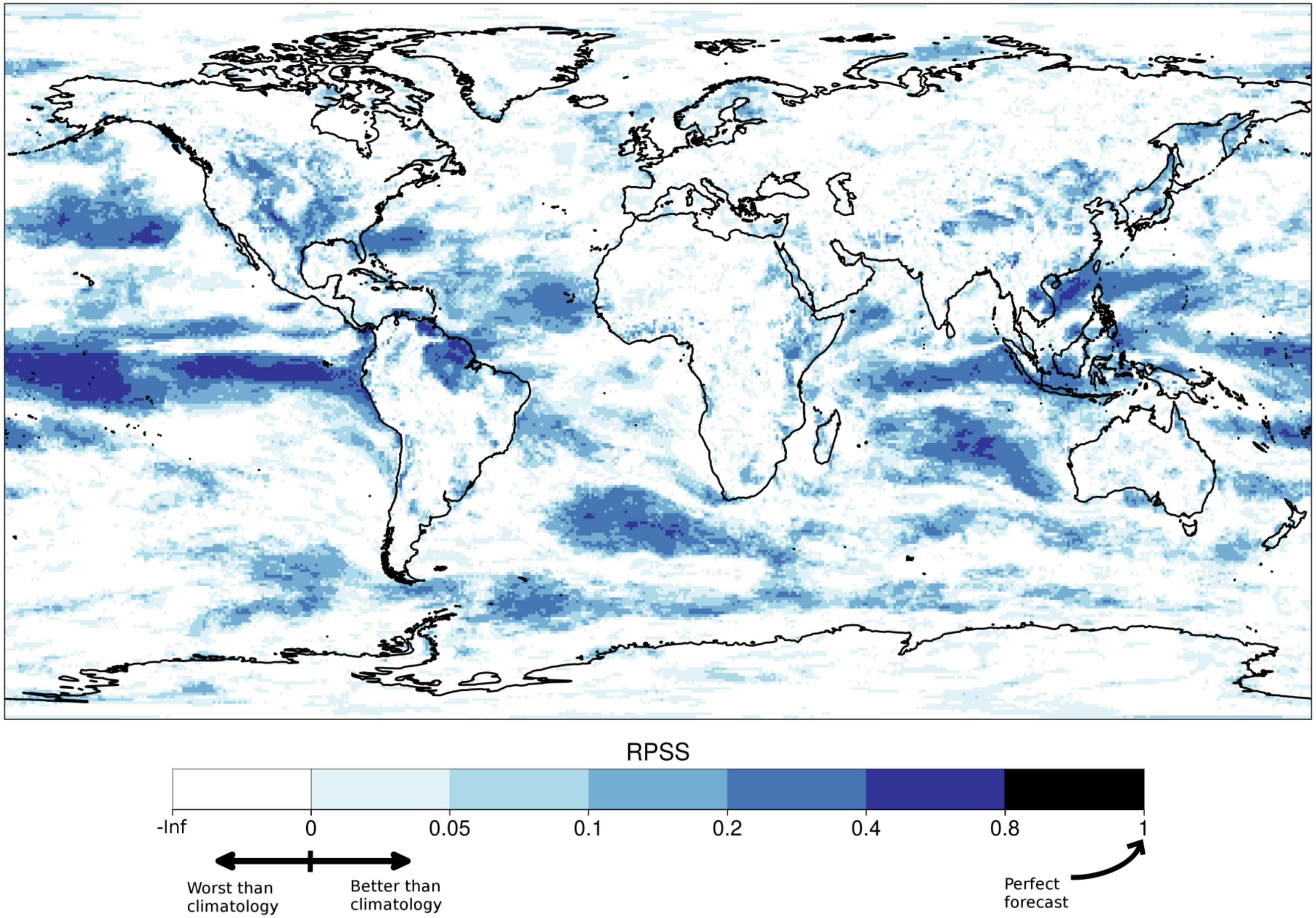
Skill



Skill assessment for DJF (1981-2013)

Displaying: Ranked Probability Skill Score [RPSS]

"A prediction has no value without an estimate of forecasting skill based on past performance"

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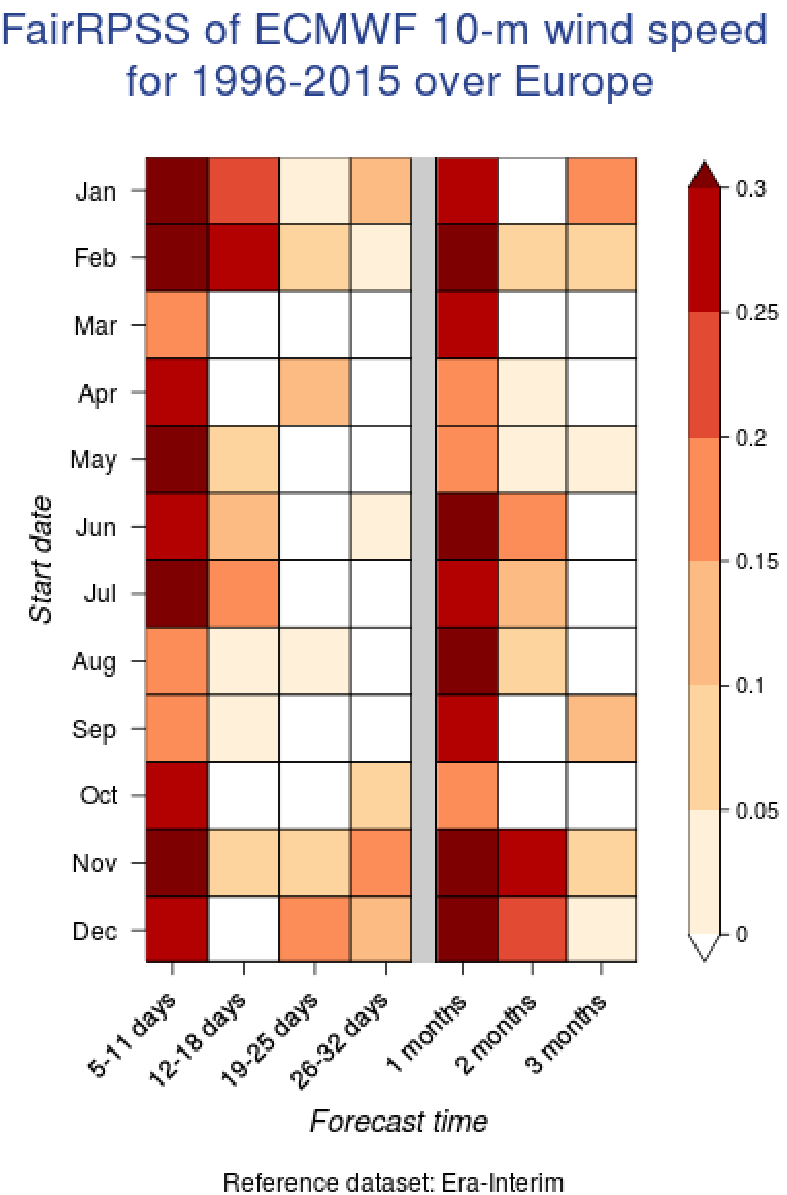
NEWA project, predictability



NEW EUROPEAN WIND ATLAS
newa

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Case study: wind drought in US

Lledó et al., 2018: Investigating the effects of Pacific sea surface temperatures on the wind drought of 2015 over the United States. Journal of Geophysical Research

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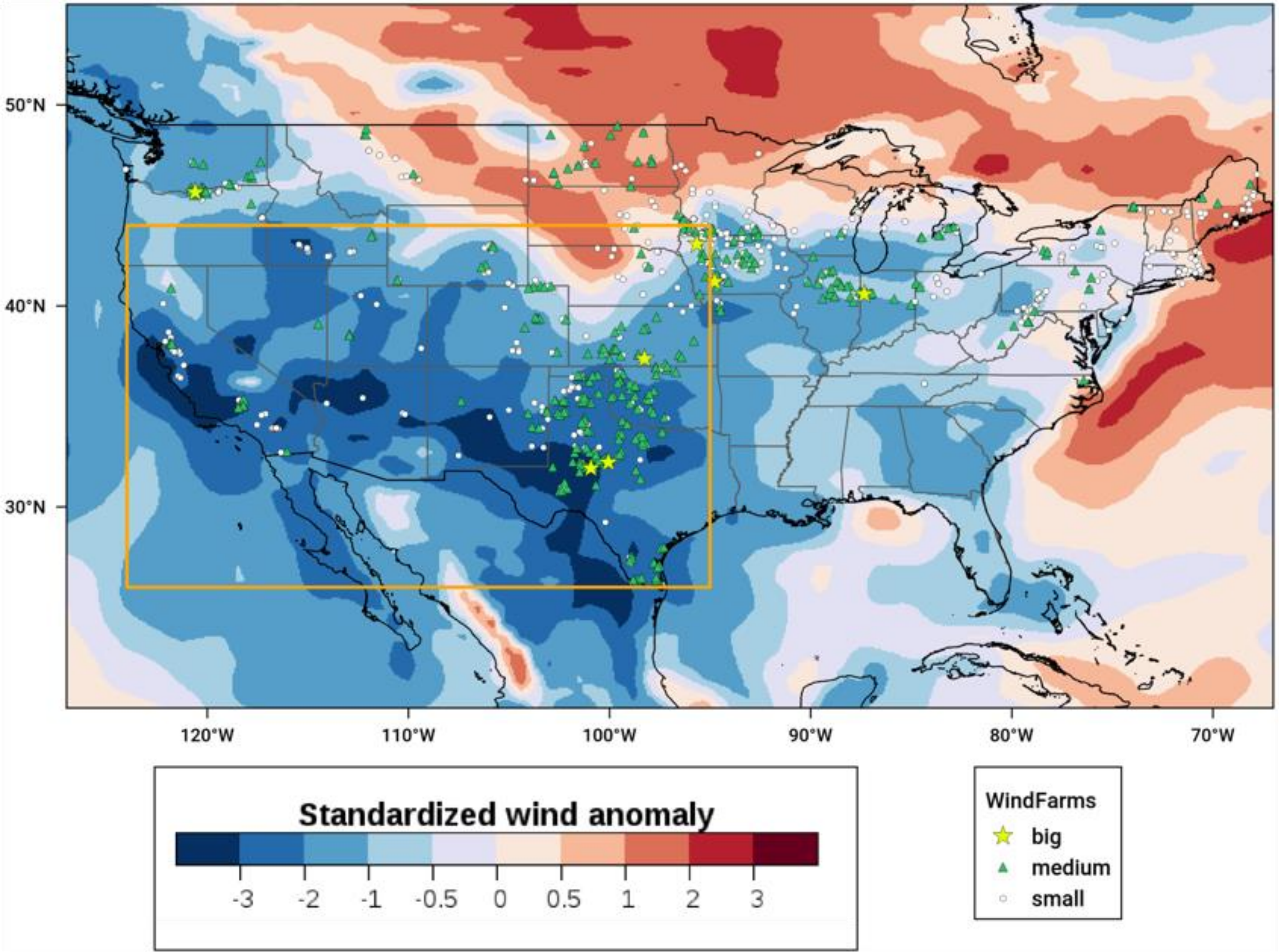
Wind drought in US

During the first quarter of 2015 the United States experienced a widespread and extended episode of low surface wind speeds. This episode had a strong impact on wind power generation. Some wind farms did not generate enough cash for their steady payments, and the value of wind farm assets decreased.



Wind speed anomalies reflecting the wind drought over the United States for the first trimester of 2015. The US wind farm fleet is also shown.

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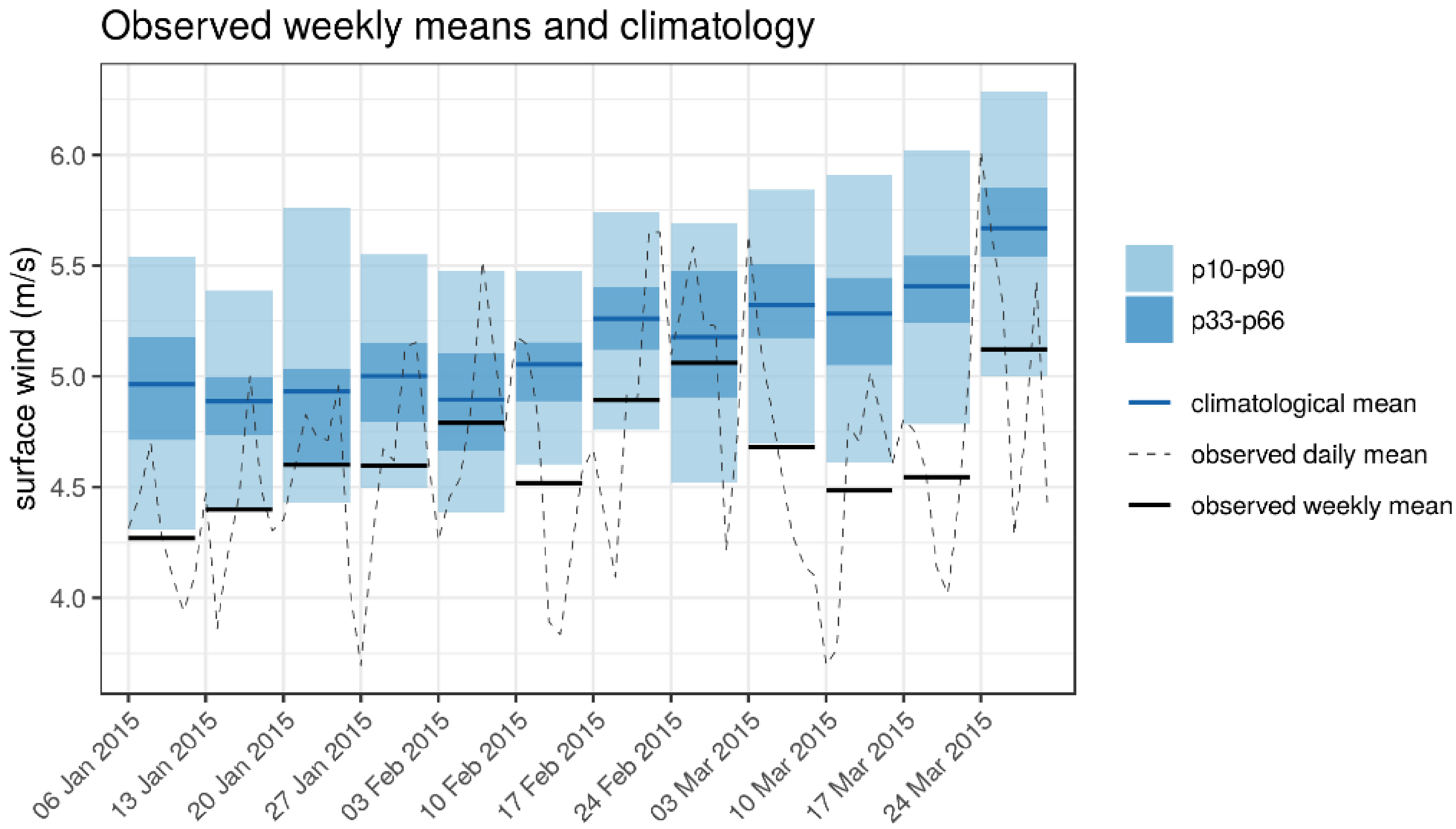

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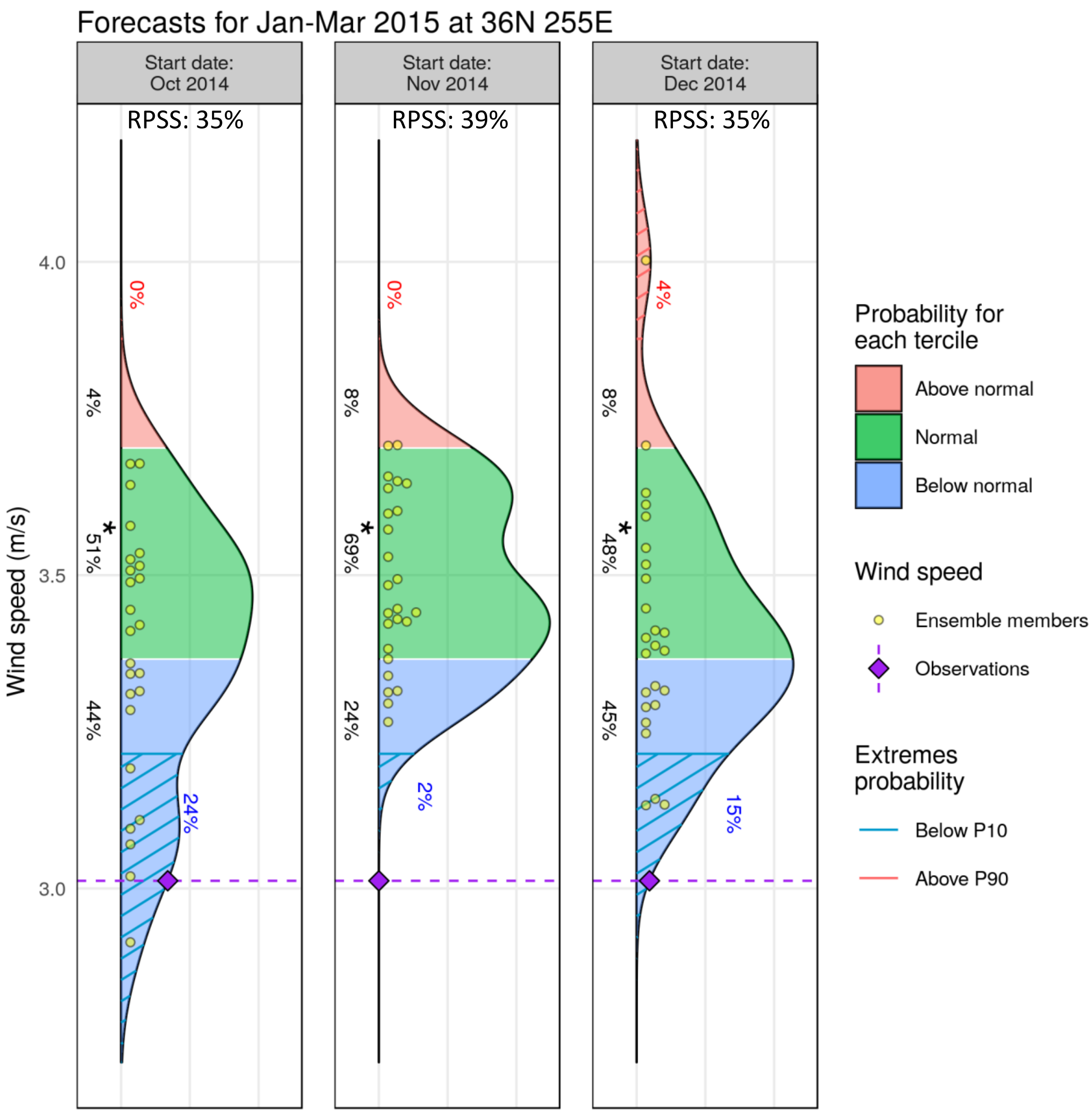
Available seasonal forecast



System: ECMWF S4
Reanalysis: ERA-Interim
Bias adjusted –calibrated
Hindcast: 1993-2015
37N 105W

Which decisions would you take in view of those forecasts?

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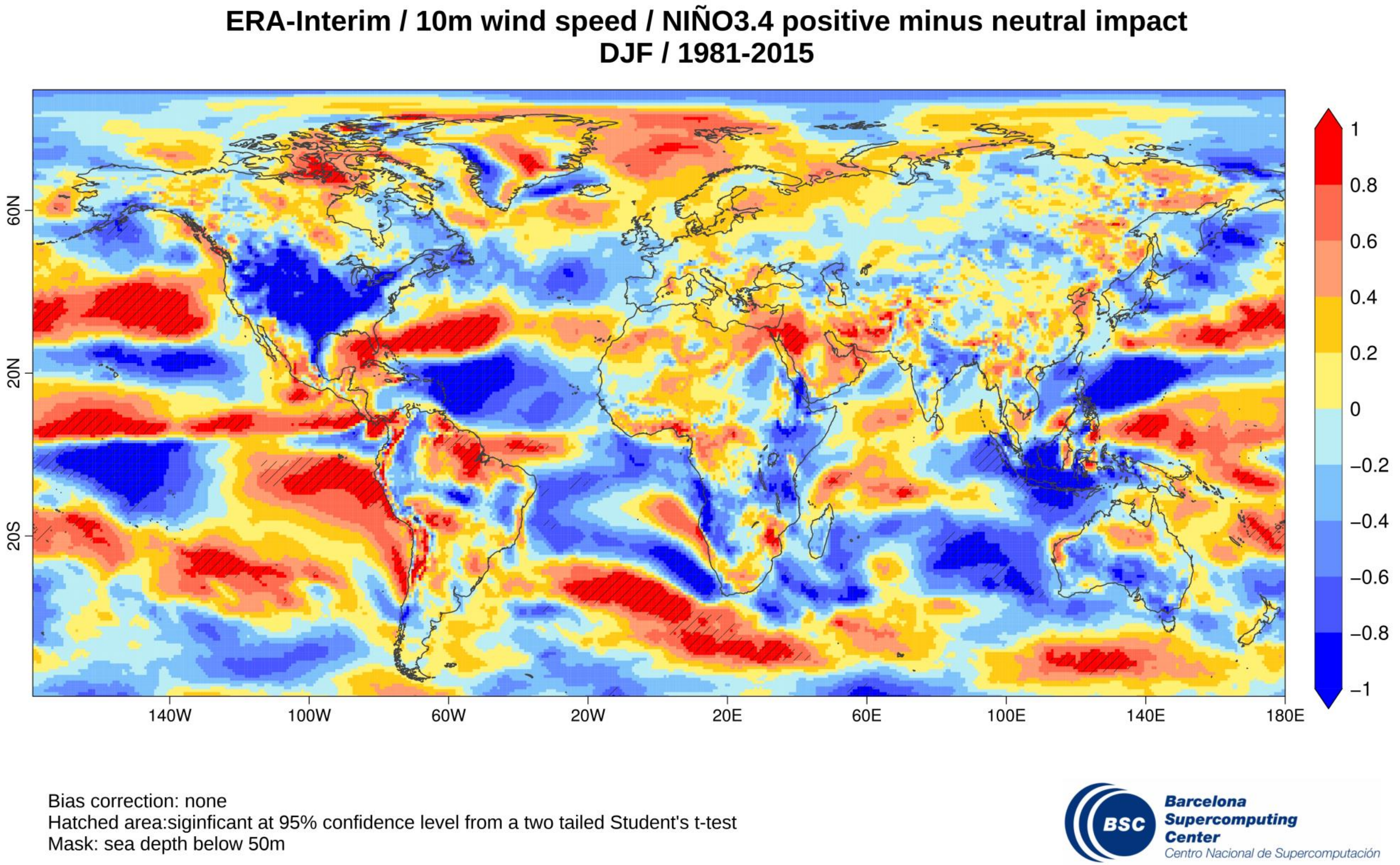
NIÑO3.4 teleconnection



Impact maps between NIÑO3.4 teleconnection index 10m wind speed from ERA-Interim reanalysis.

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

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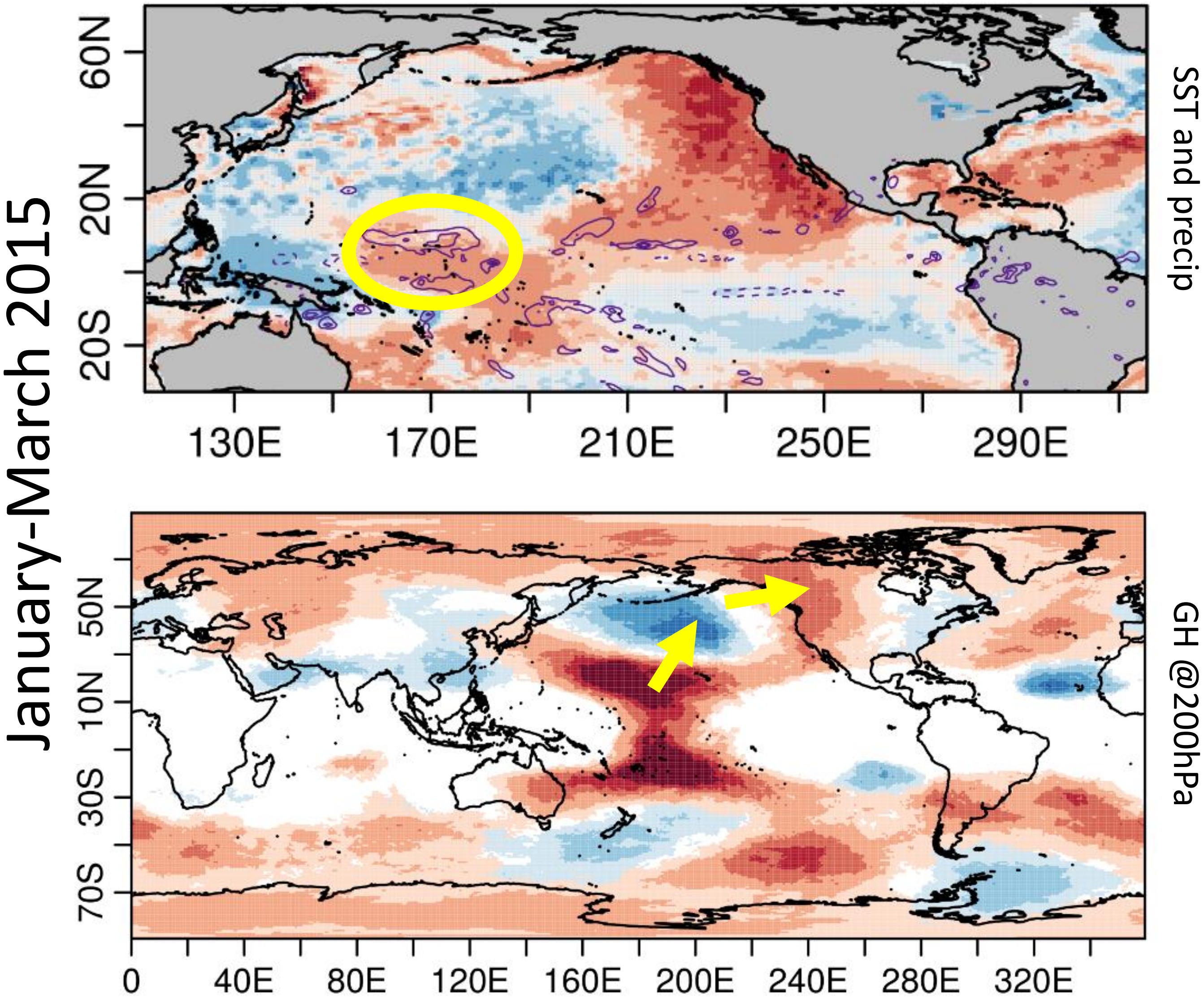
Causes



High SSTs in western tropical pacific
↓
Enhanced convection in the area
↓
Upward flow produces divergence at 200hPa
↓
Rossby wave propagates to North America
↓
Results in persistent low winds

System: EC-EARTH

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Case study: heat wave and wind drought in Spain. Sep 2016

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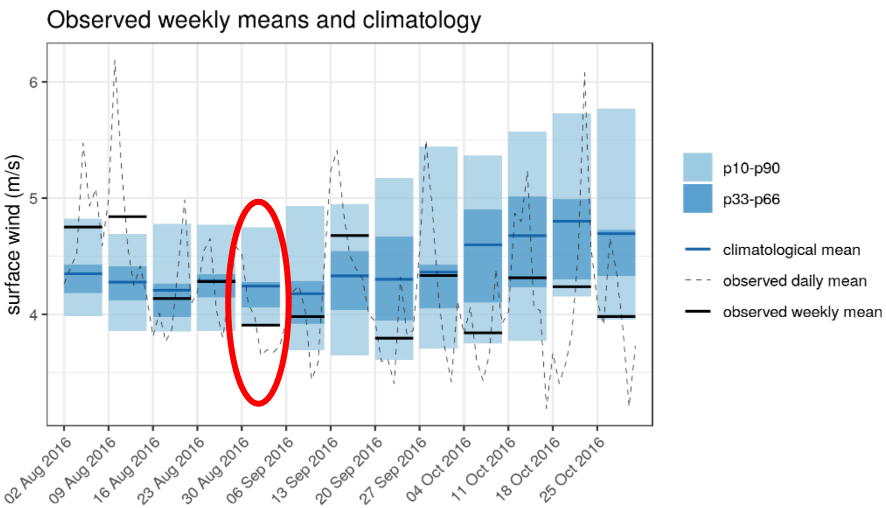
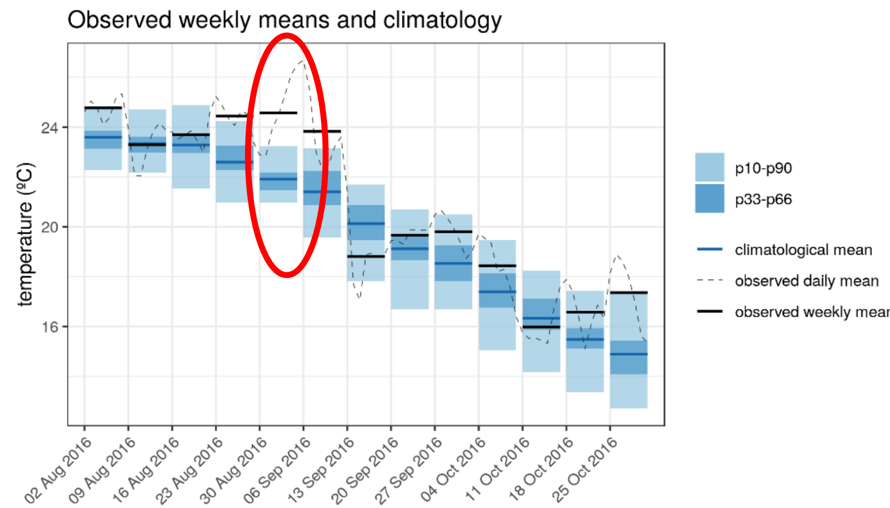
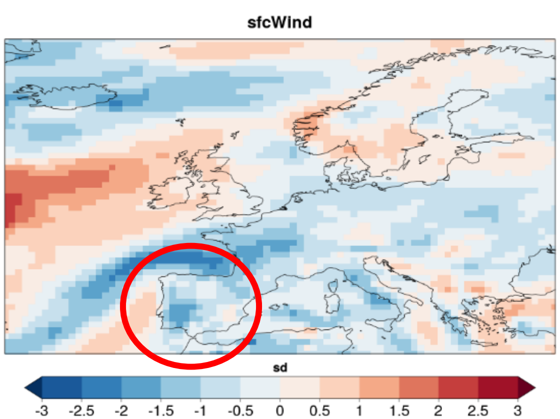
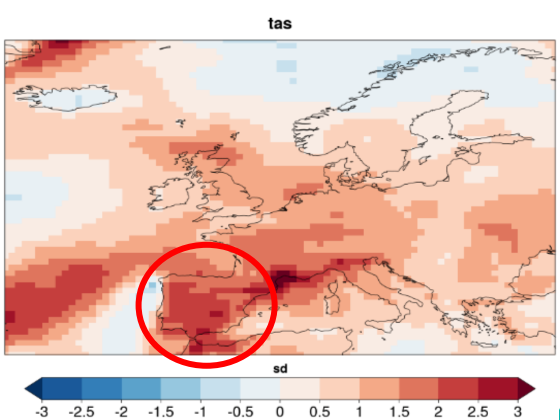
Heat wave and wind drought in Spain. Sep 2016









Surface wind and temperature standardized anomalies for the week 30/08/2016-5/09/2016.
ERA-Interim with respect to climatology (1981-2017)

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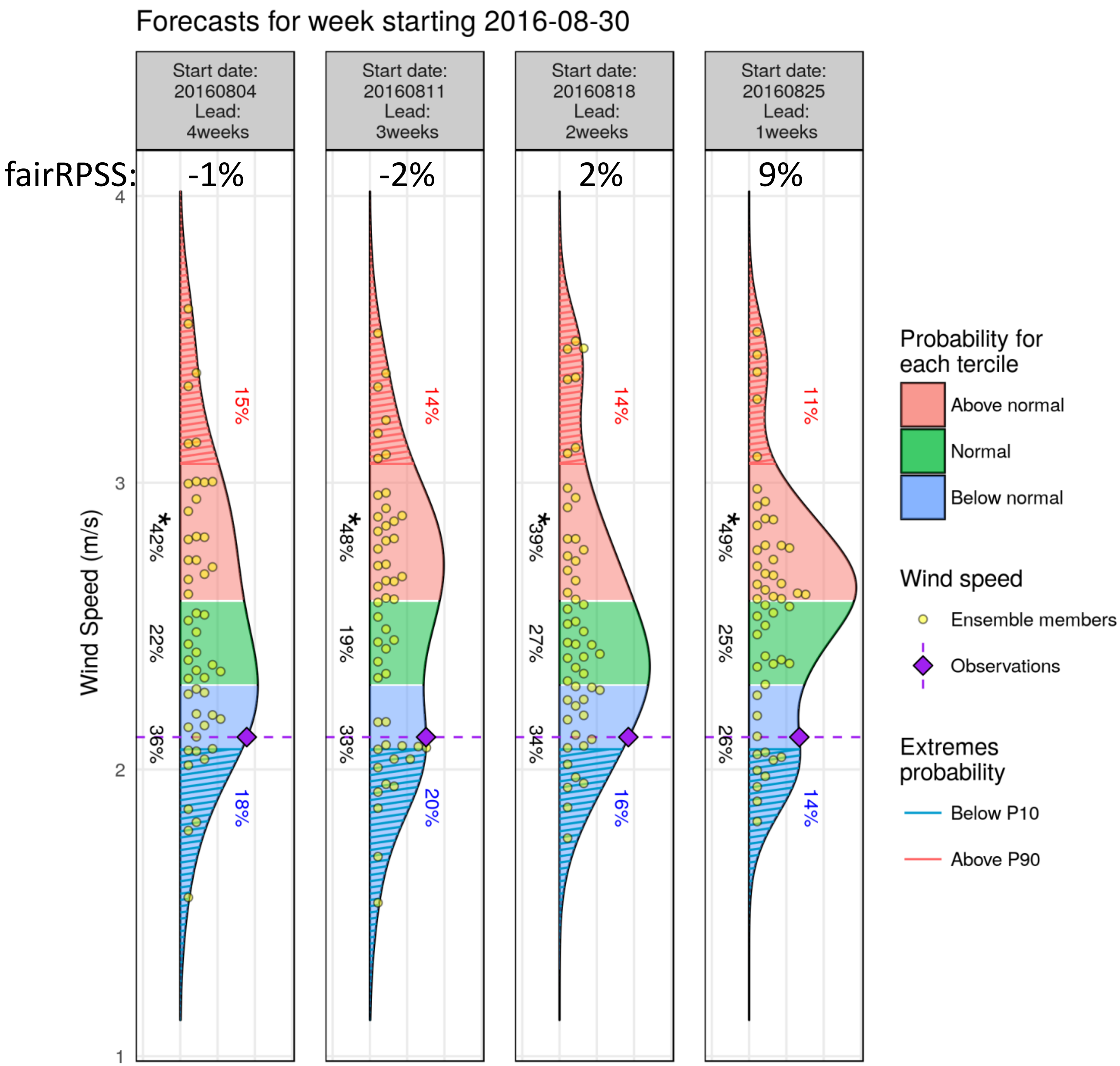
Forecast available: wind speed



System: ECMWF monthly prediction system
Reanalysis: ERA-Interim
Bias adjusted –calibrated
Hindcast: 1996-2015
Lat= 40.5 N/Lon = 358.5 E

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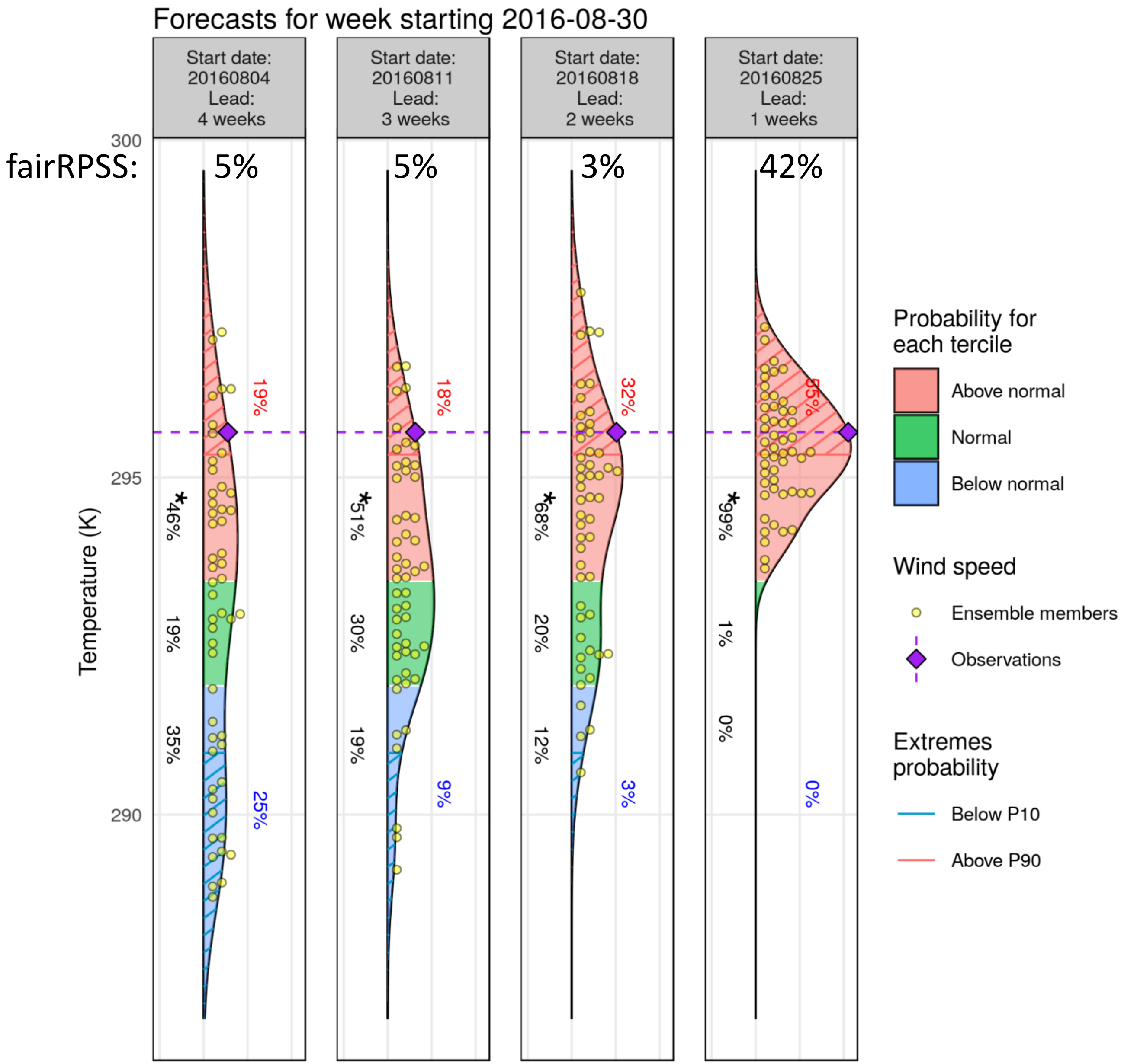
Forecast available: temperature



System: ECMWF monthly prediction system
Reanalysis: ERA-Interim
Bias adjusted –calibrated
Hindcast: 1996-2015
Lat= 40.5 N/Lon = 358.5 E

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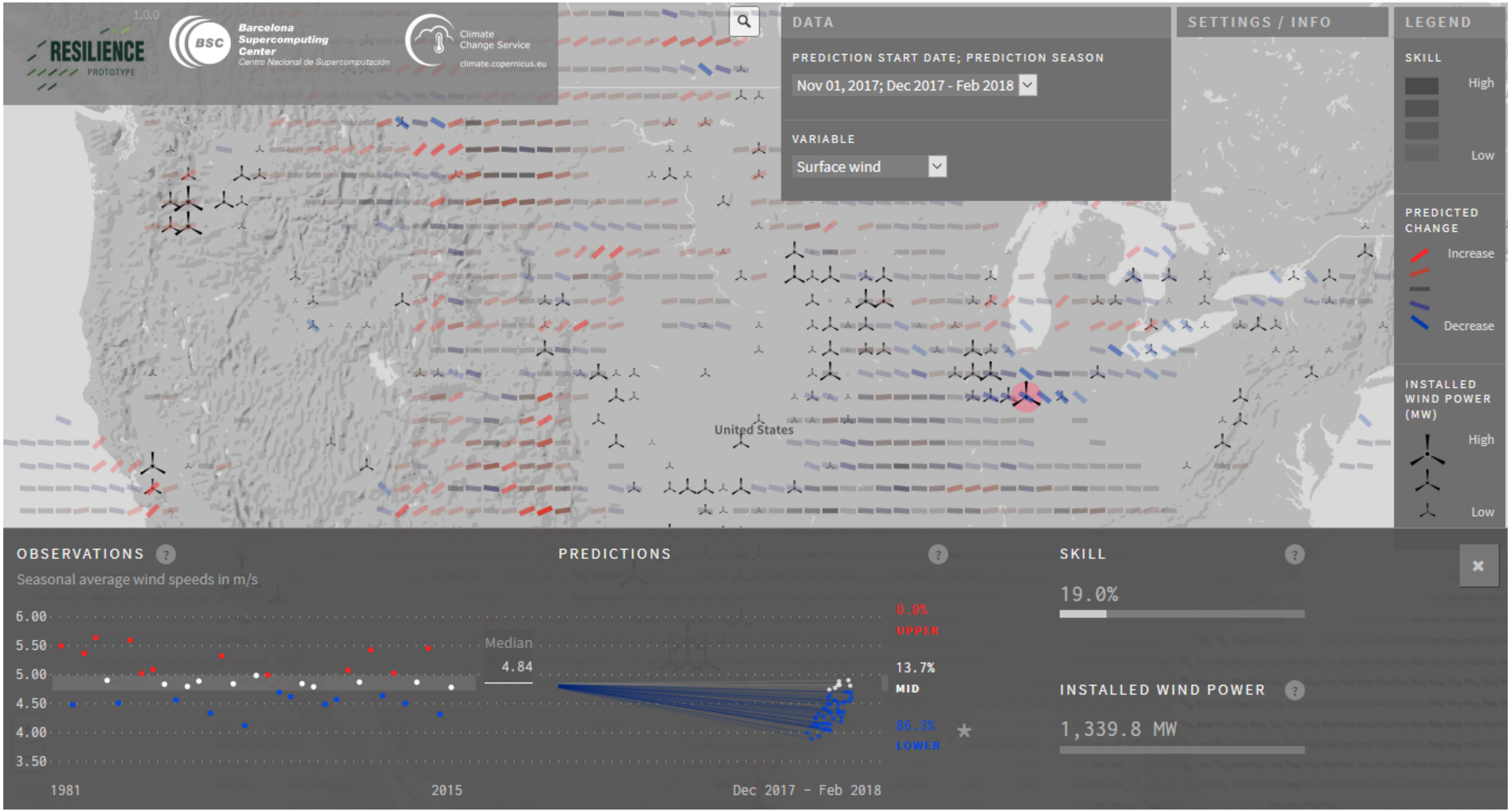
DST



http://www.bsc.es/ess/resilience/map.html

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Final remarks

- Climate prediction systems have improved in the last decade demonstrating that probabilistic forecasting can inform better decision making at some temporal scales and regions
- Alongside the model development process, climate predictions need to be evaluated on past years to provide robust information before making decisions
- Tailored service helpful for several applications
- Interdisciplinary groups enhance the interaction with users to co-develop a service

Future work:

- multi-model ensembles
- to improve the utility of forecasts by incorporating skillful information of the large-scale teleconnection patterns at different time scales

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Thank you

Get in touch for more information!

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Consortium

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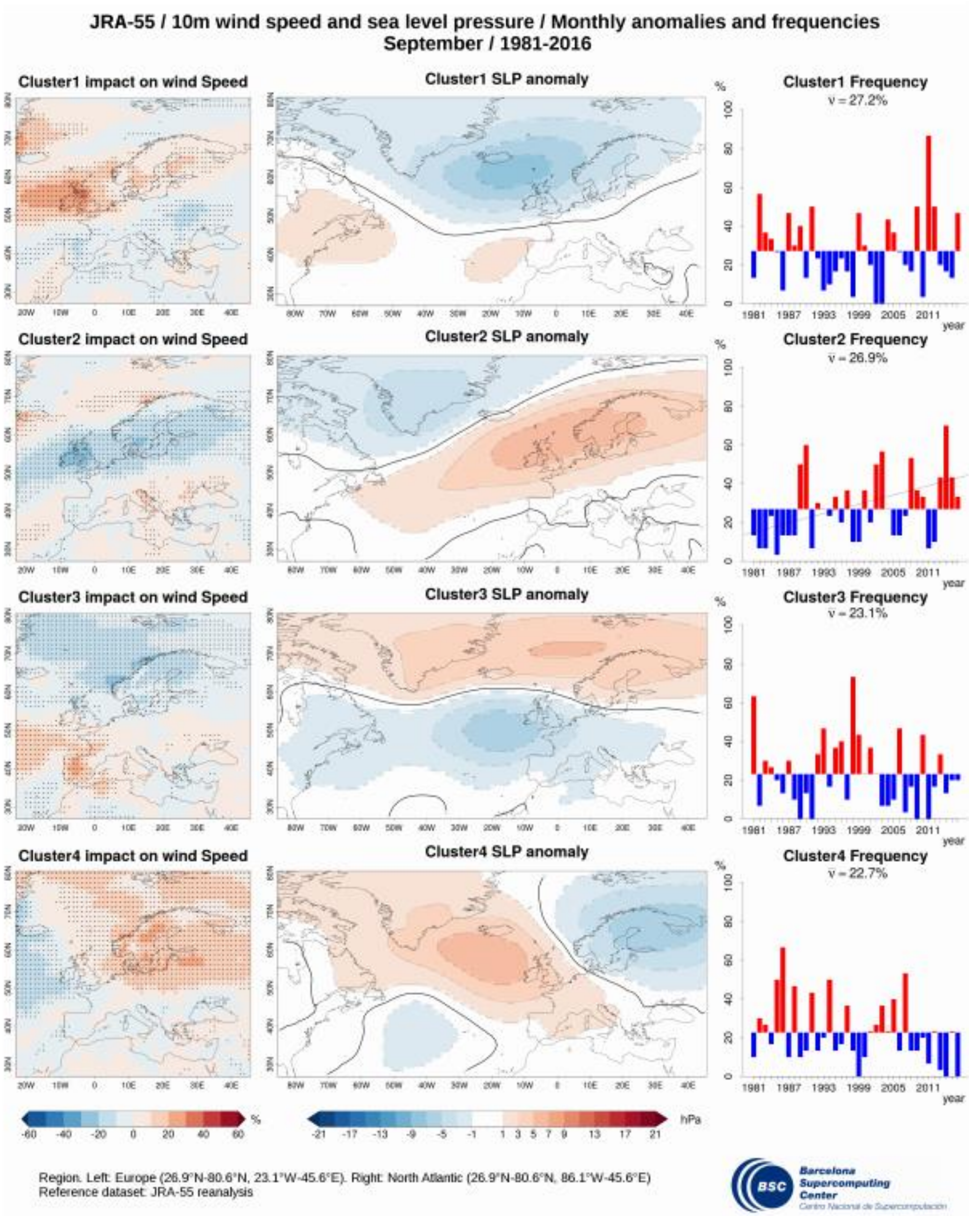
Causes



Center column: monthly SLP anomalies (in hPa) corresponding to the four Euro-Atlantic clusters (weather regimes) in September over the period 1981-2016, in decreasing order of explained variance.

Right column: monthly frequency of occurrence of the four clusters in September for 1981-2016. Eventual presence of black lines indicate significant trends.

Left column: impact of the four clusters on 10-m wind speed. Impact (in %) is relative to the average wind speed for the month of September over the period 1981-2016. Black dots indicate significant points with a t-test at 95% confidence level. (Source: JRA-55 reanalysis)

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Capacity factor

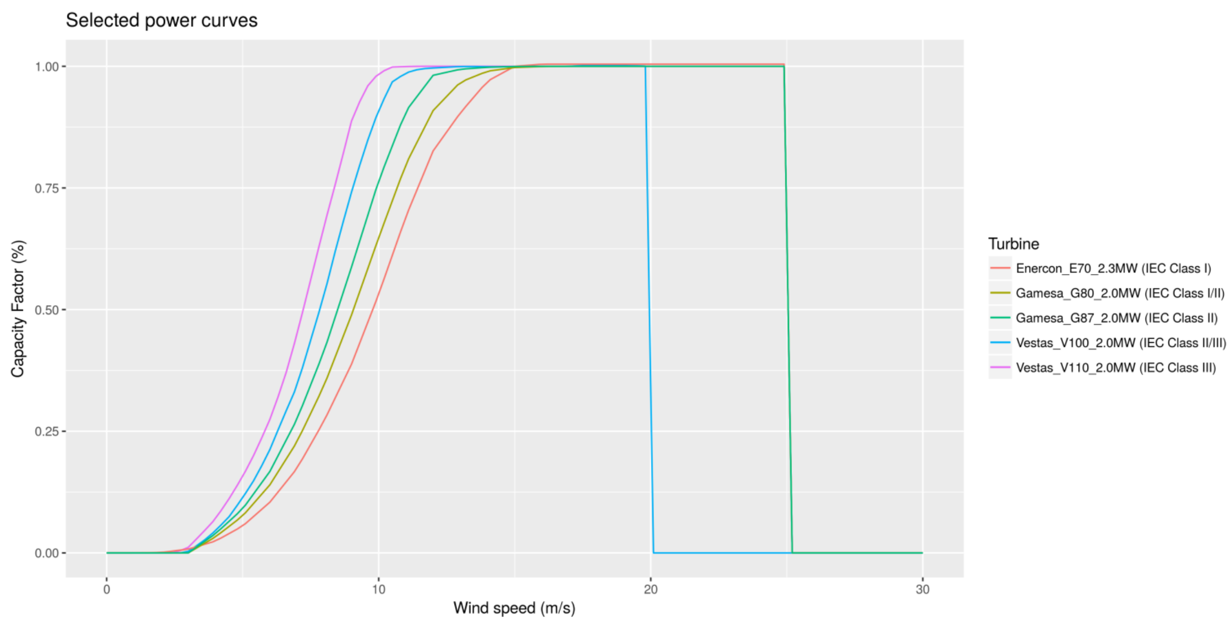
Capacity factor is a good indicator of wind power generation.

Is independent of:

- number of installed turbines
- nameplate capacity of installed turbines

Using manufacturer power curves for three turbines representing IEC classes.

Fed with: 6-hourly model data, sheared at 100m.



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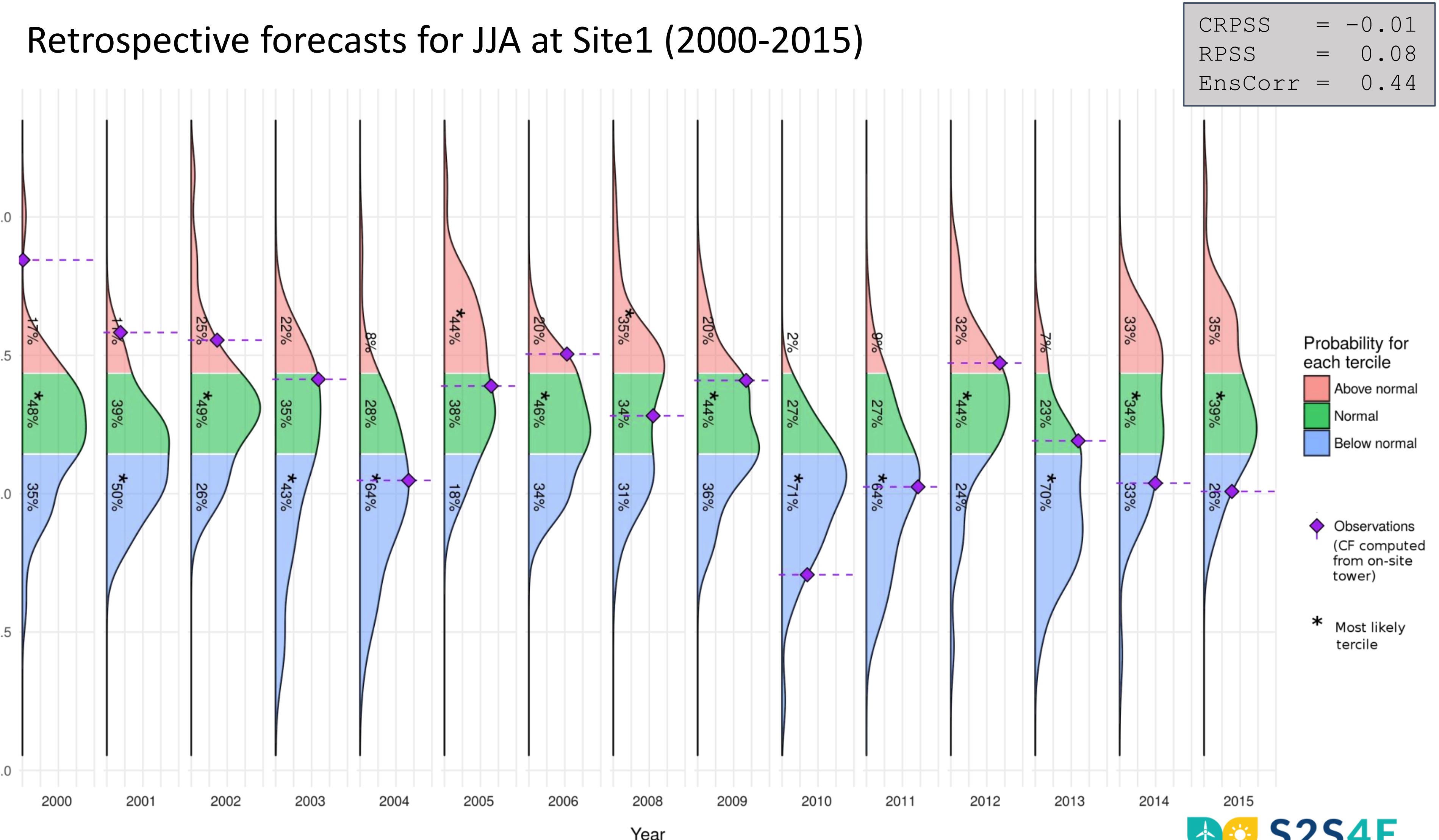
Capacity factor

Retrospective forecasts for JJA at Site1 (2000-2015)



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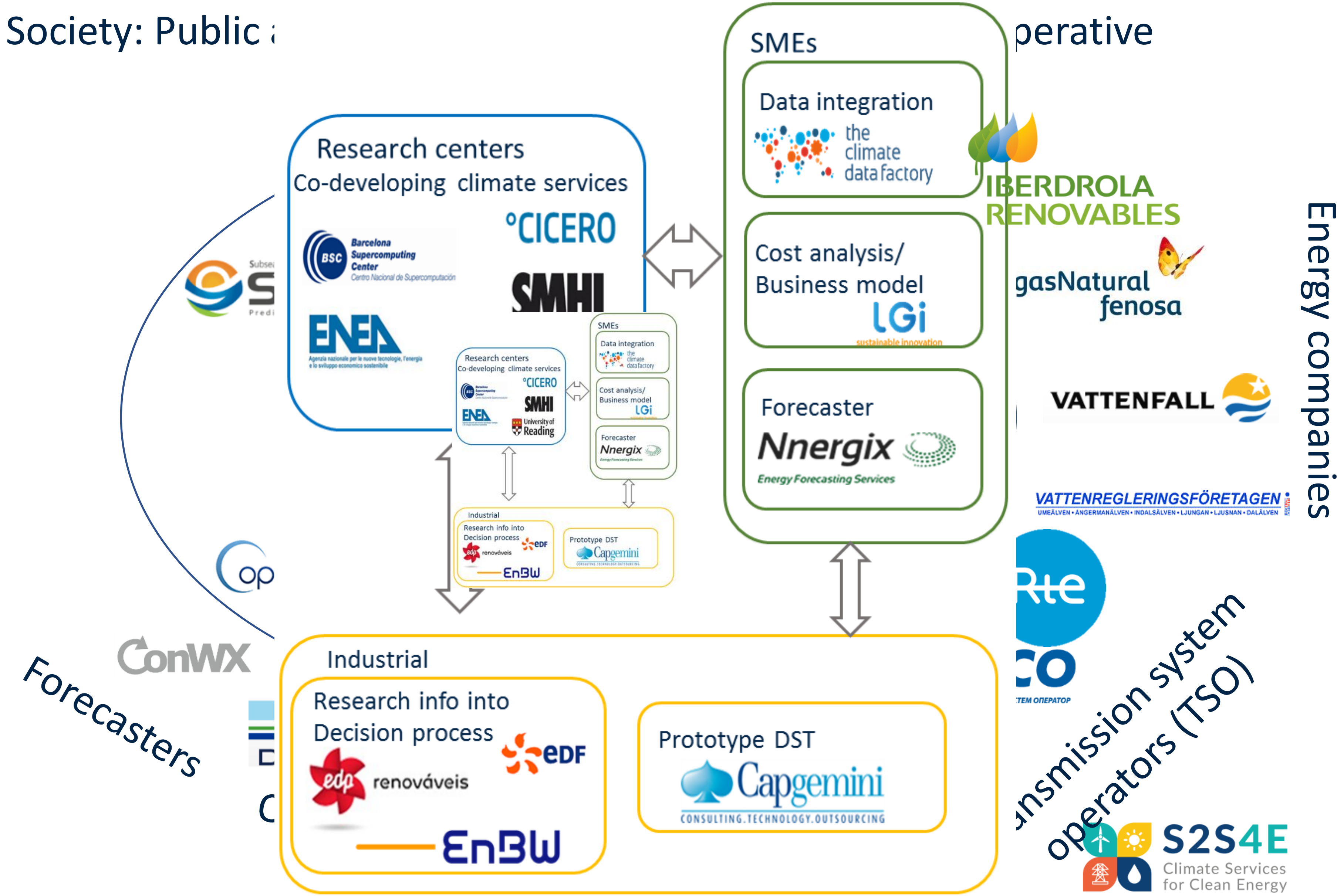
Society: Public
perative
SMEs
Data integration
the climate data factory
Cost analysis/ Business model
LGi
sustainable innovation
Forecaster
Nnergix
Energy Forecasting Services
Research centers
Co-developing climate services
Barcelona Supercomputing Center
Centro Nacional de Supercomputación
CICERO
SMHI
ENEA
University of Reading
Industrial
Research info into Decision process
edp renováveis
EDF
EnBW
Prototype DST
Capgemini
CONSULTING.TECHNOLOGY.OUTSOURCING
IBERDROLA RENOVABLES
gasNatural fenosa
VATTENFALL
VATTENREGLERINGSFÖRETAGEN
UMEÄLVEN • ÅNGERMANÄLVEN • INDALSÄLVEN • LJUNGAN • LJUSNAN • DALÄLVEN
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Rte
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ConWX
Forecasters
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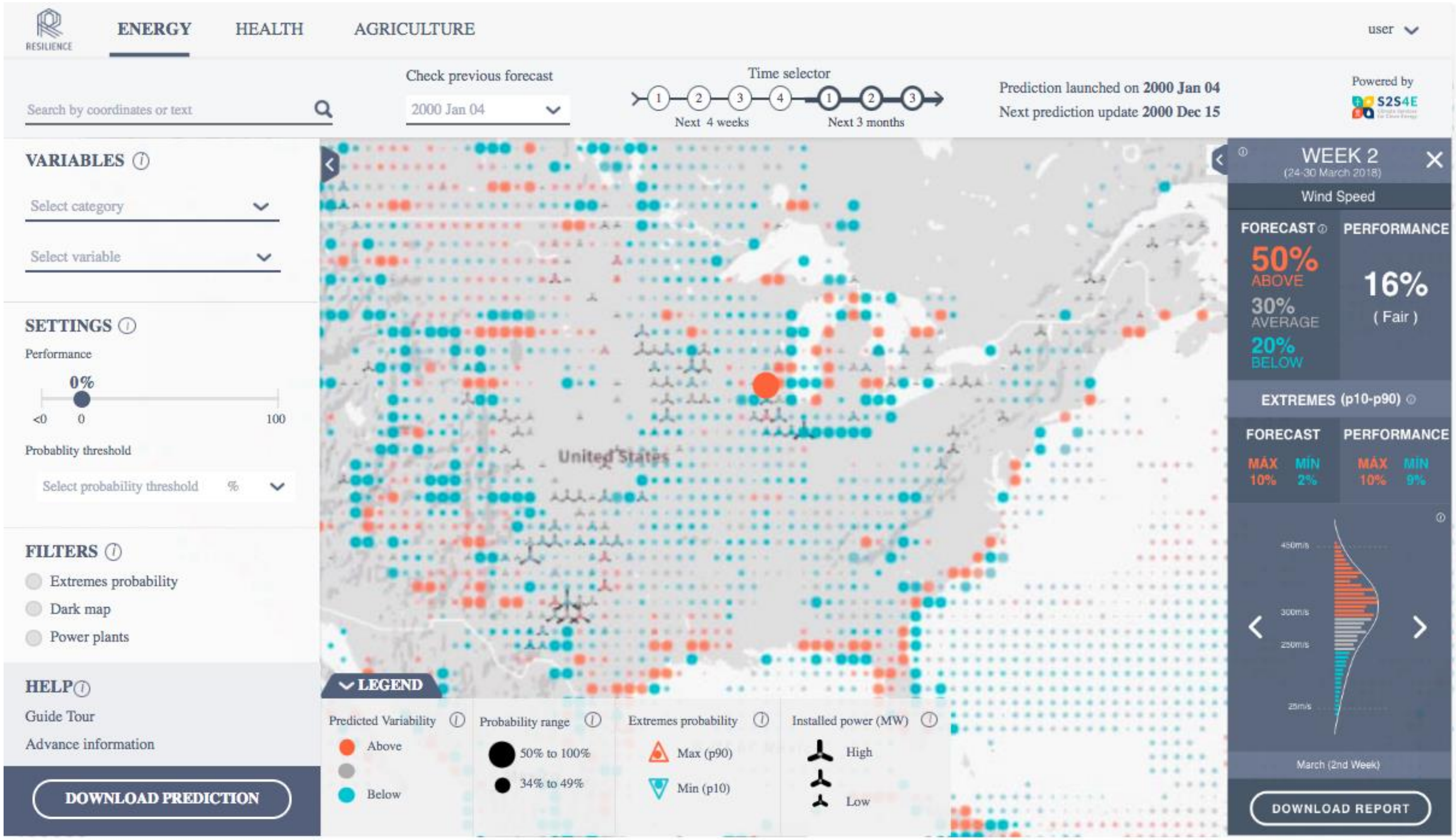
Success criteria is TRUST



http://www.bsc.es/ess/resilience/map.html

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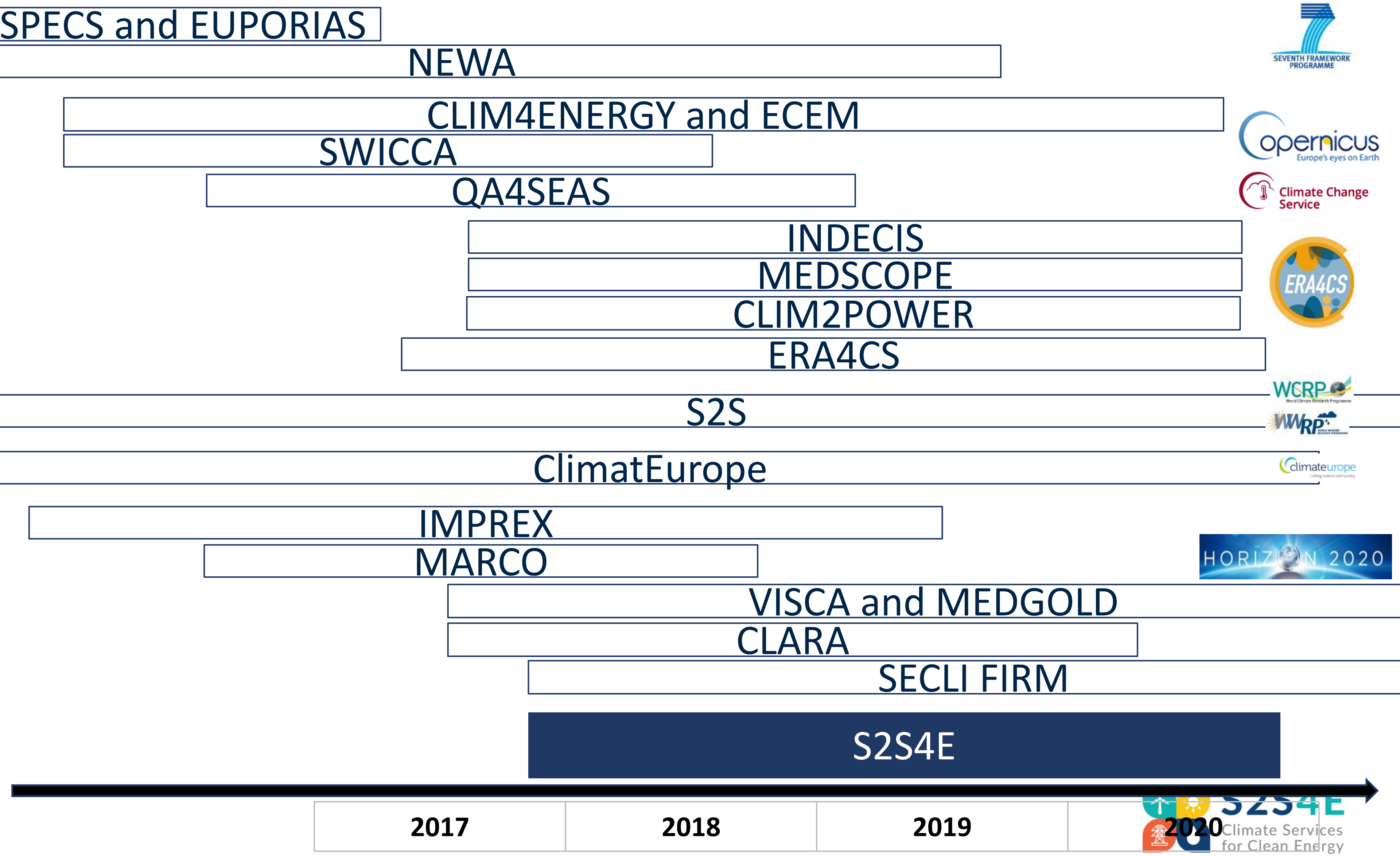
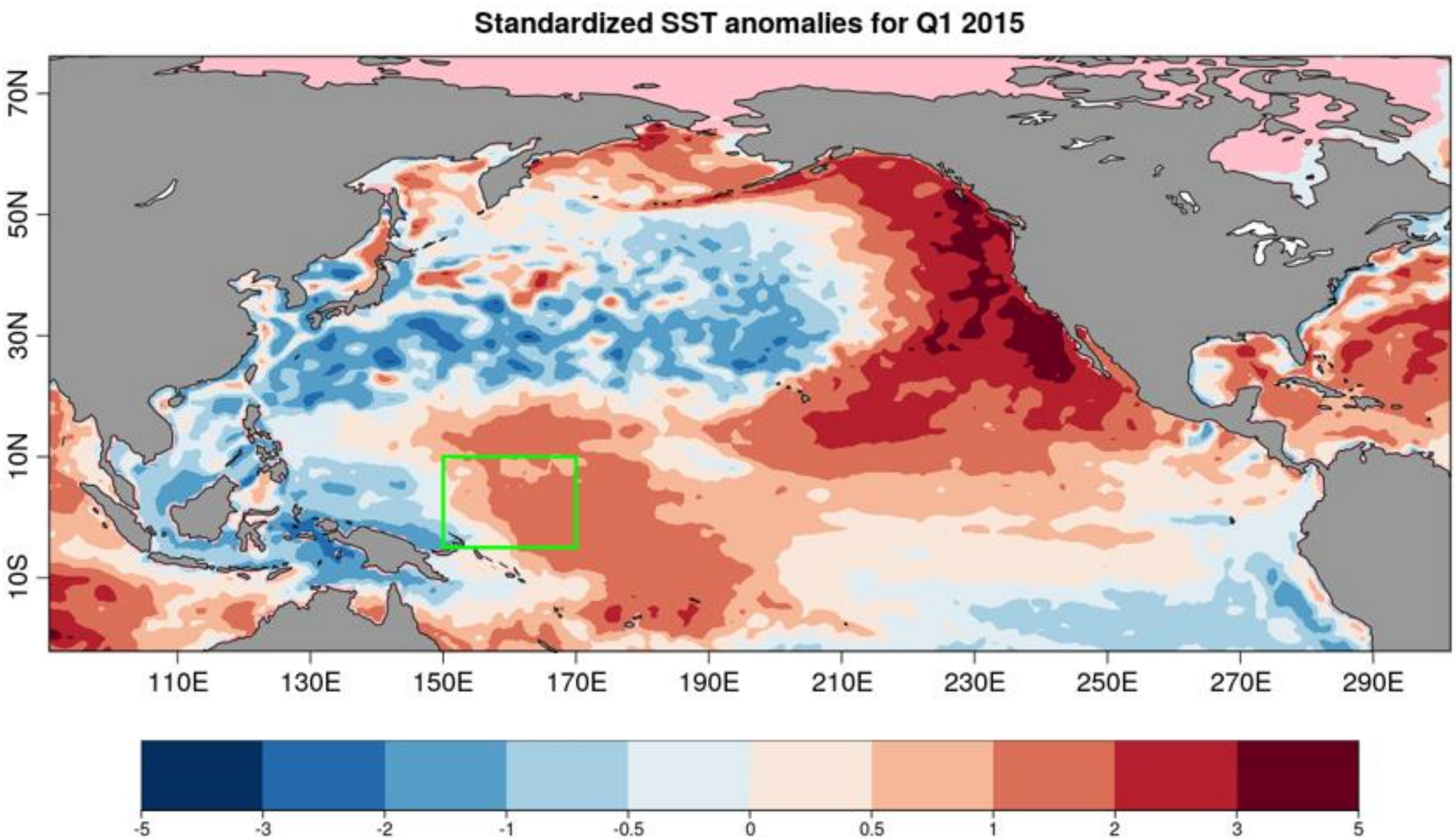
Synergies with other projects



Why?

Using retrospective climate predictions, we find that high ocean temperatures in the western tropical Pacific Ocean played a central role to establish and maintain those wind anomalies. This is not a single event. This work shows that the wind speed variability in the United States is not only dominated by El Niño but also by the ocean temperatures in this region of the Pacific.



Sea surface temperature anomalies in the Pacific Ocean during the same period. The green box shows the area under study.

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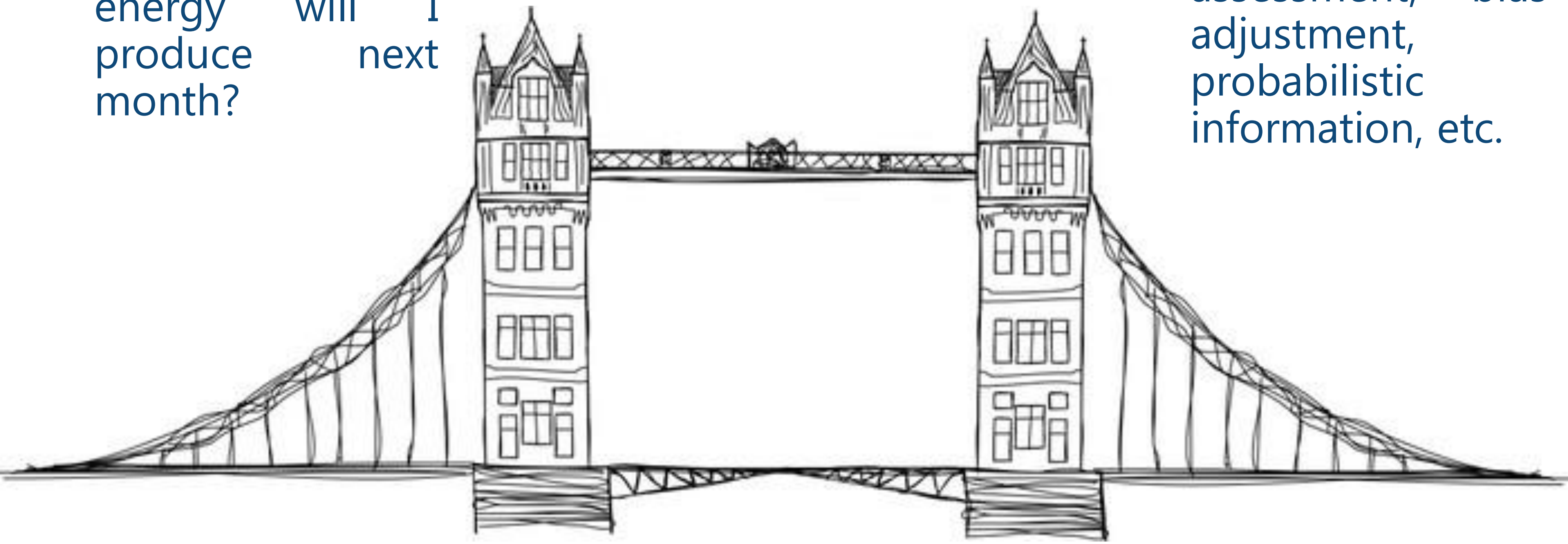
Climate services

- User: How much energy will I produce next month?
- Scientist: Skill assessment, bias adjustment, probabilistic information, etc.



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